BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

B71 01039

SUBJECT: Population Distribution and Terrain Masking Considerations in Selection of Space Shuttle Launch and Recovery Sites - Case 900

DATE: January 15, 1971

FROM: A. G. Weygand

ABSTRACT

[redacted]

It is expected that the Space Shuttle will be designed and operated to have the same reliability as commercial aircraft. However, the safety of the population centers located around potential Space Shuttle launch sites in the event of a non-safe Space Shuttle abort needs to be considered. It is assumed that the risk to population centers from a Space Shuttle abort will be acceptable after the predicted zerolift instantaneous impact point of the Space Shuttle reaches a speed which exceeds three nautical miles per second which occurs at a predicted impact distance of about 200 nautical miles from the launch site. The population distribution was examined in the area within 200 nautical miles of the three candidate launch sites; namely, (a) Kennedy Space Center (KSC), (b) Holloman Air Force Base (AFB), and (c) Edwards AFB. It was found that the orbit inclinations of major interest for Space Shuttle missions (assumed to extend from launch site latitude to 100 degrees) can be reached with an in-plane launch from either a Cape Kennedy or an Edwards AFB launch site without endangering the safety of major population centers (cities with populations exceeding 10,000 inhabitants) or foreign territories (Mexico or Bahamas). However, the Cape Kennedy launch site provides greater launch azimuth flexibility and population safety than the Edwards AFB site. Although the total number of inhabitants within 200 nautical miles of a Holloman AFB site is by far exceeded by that around either a Cape Kennedy or an Edwards AFB launch site, the smaller number of densely populated areas are more evenly distributed around the Holloman AFB site resulting in more hazard exposure for the in-plane launch azimuths of interest.

Consideration is given to terrain masking of the runway at the launch/recovery sites of interest to determine if the terrain will interfere with the landing approach glide slope of either the Booster or the Orbiter which is assumed to be 2.5 degrees above the local horizontal. It was found that the terrain masking at any selected azimuth at either the Cape Kennedy or the Edwards AFB launch/recovery site will be less than 2.0 degrees. Terrain masking at the Holloman AFB launch/recovery site will exceed 2.5 degrees at selected azimuths in the range extending from 70 to 120 degrees, being as much as four degrees in some instances.

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MEMORANDUM FOR FILE

1.0 INTRODUCTION

According to current planning in the Space Shuttle Program, the Space Shuttle launch site will be co-located with the primary recovery (or landing) site for both the Booster and the Orbiter of the Space Shuttle. Two items are discussed in this memorandum concerning the physical surroundings of any potential location for such a launch/recovery site which should be considered in a trade-off between competing site locations. They are: (a) proximity of densely populated areas which could constitute a safety problem if non-safe mission aborts should occur, and (b) terrain masking which could interfere with the desired landing approach glide slope path of either the Booster or Orbiter upon its return at the end of its space or ferry flight mission. These two items are discussed below with respect to the following candidate Space Shuttle launch/recovery site locations: (a) the Kennedy Space Center located at Cape Kennedy, (b) Holloman Air Force Base (AFB) located near Alamagordo, New Mexico, and (c) Edwards AFB located in Southern California.

2.0 POPULATION DISTRIBUTION

The current Shuttle requirements call for the Space Shuttle to have an all-azimuth launch capability. This capability has been specified to insure Space Shuttle flexibility and preclude any Space Shuttle design peculiarities which could deny launch at selected azimuths. It is likely, however, that most, if not all, Space Shuttle missions will require the Orbiter to be launched into posigrade orbits (e.g., for Space Station logistics resupply missions, unmanned satellite delivery or retrieval missions), polar or near polar orbits, or sun-synchronous orbits. These translate into a probable range of desired orbit inclinations extending from 0 to 110 degrees corresponding to launch azimuths (assuming an in-plane launch) from 0 to 200 degrees and from 340 to 360 degrees where a 0 degree (or 360 degree) azimuth launch corresponds to a launch in a due northerly direction.

In general, the Space Shuttle can be launched in-plane into an orbit with a given inclination on either of two azimuths, one in a net northerly direction and one in a net southerly direction which are symmetrically located in degrees with respect to an azimuth of 90 (or 270) degrees, depending upon whether the desired orbital direction is ascending (increasing in latitude) from the launch site or descending from the launch site at the time of launch. The limited Shuttle payload capability makes in-plane launchings (no dog-leg maneuver) very desirable. It should be noted that for an in-plane launch, the Space Shuttle cannot be inserted into any orbit with an inclination less than the latitude of the launch site or greater than 180 degrees minus the latitude of the launch site. The approximate latitudes of the launch sites of interest are: (a) 28° 30' N for Cape Kennedy, (b) 32° 51' N for Holloman AFB, and (c) 34° 51' N for Edwards AFB.

The current Space Shuttle requirements include an intact abort capability. This implies that the Booster and the Orbiter will be capable of separating and then separately continuing flight to a safe landing in the event of an abort during the launch. However, at the present time the entire abort question is under review. It is clear that impact of an intact Booster or Orbiter partially loaded with liquid hydrogen and liquid oxygen could result in a dangerous explosion. It is apparent that if a Space Shuttle intact abort capability can be assured with sufficiently high probability, the proximity of densely populated areas to the launch site will have a small effect from a safety standpoint in the trade-off study of competing site locations. Since this probability of intact abort is not unity, the surrounding population needs to be considered.

It has been estimated that the motion of the zerolift instantaneous impact point of the Space Shuttle on the Earth's surface will be progressing at a rate in the order of 3 to 3.5 nautical miles per second by the time the instantaneous impact point has reached 200 nautical miles (approximately 230 statute miles) down range from the launch site. For the purposes of this analysis, it was assumed that the dwell time of the instantaneous impact point in a particular area beyond 230 statute miles down range would be sufficiently short that the probability of Space Shuttle impact in that area in the event of a non-safe abort would be tolerable. In order to make analysis tractable, only incorporated places with populations exceeding 10,000 inhabitants were considered in the 230 statute mile radius from the launch site. These places were determined from the preliminary reports of the 1970 census of population for the appropriate states as published by the U. S. Department of Commerce.

A list of these incorporated cities with approximate population which are located within a 230 statute mile radius from Cape Kennedy, Holloman AFB, and Edwards AFB is given in Tables 1, 2, and 3, respectively. The approximate azimuth location and down range distance of each one of these incorporated places with respect to the assumed launch site location were obtained graphically through the use of commercial oil company road maps and are included in Tables 1, 2, and 3, respectively, for the possible launch sites considered. All cities whose azimuth locations overlap are listed alphabetically in these Tables and an overall azimuth range including all of these cities is given. The approximate azimuth location information on population centers for each of the three competing launch site locations are shown and compared graphically in Figure 1. Also included in Figure 1 are the azimuth locations of all foreign-controlled territory (Mexico and Bahama Islands) within 230 miles of each of the three launch sites under consideration. Assuming only in-plane launches of the Space Shuttle, the orbit inclination angles which will be precluded if the instantaneous impact point of the Space Shuttle must never fall within the confines of these incorporated cities which are located within 230 statute miles of the launch site are also included in Tables 1, 2, and 3 for each of the three respective launch sites and are compared graphically in Figure 2.

It is recognized that the accuracy of the azimuth location and range determinations for each of the cities and foreign-controlled territories with respect to the appropriate launch site is not great because of the maps and graphical methods used. Furthermore, the azimuth location of a city from the launch site is rather sensitive to the precise location of the launch pad, which has been chosen arbitrarily in the general launch area in this analysis, because of the relatively short ranges involved. However, for the purposes of this analysis, it was desired only to provide sufficiently accurate data to obtain the order of magnitude of this potential problem at each launch site location of interest and to permit a rough but meaningful comparison between site locations.

Although the total number of incorporated cities with populations exceeding 10,000 inhabitants within 230 statute miles of the possible Cape Kennedy and Edwards AFB Space Shuttle launch sites far exceed the number within 230 statute miles of the possible Holloman AFB launch site, the cities are more evenly distributed in azimuth location around Holloman AFB than around either Cape Kennedy or Edwards AFB where they are bunched in certain azimuth locations. As can be seen from Figure 2, most of the orbits of interest (assumed to be orbit inclinations ex-

tending from 0 to 110 degrees with special emphasis on 55 degree inclination orbits, polar orbits, and sun-synchronous orbits) can be achieved with an in-plane launch in a net northerly direction from either a Cape Kennedy or an Edwards AFB launch site location without having the instantaneous impact point pass through the confines of densely populated areas. However, difficulty may be encountered in reaching polar and/or sun-synchronous orbits from a Holloman AFB location if overflying Mexico during the launch powered flight of the Space Shuttle mission is not permitted. It should be noted that for each of the three potential Space Shuttle launch site locations, orbits with low inclination angles cannot be achieved with an in-plane launch because the latitudes of these potential launch sites are different from zero degrees (equator). Net southerly launches from an Edwards AFB launch site location are almost entirely precluded under the assumed restriction against overflying densely populated areas. If overflying foreign controlled territory within 230 statute miles of the launch site is not permitted, more of the orbits of major interest in the Space Shuttle Program can be reached with launch in either of the two possible launch azimuths, one in the net northerly direction and the other in the net southerly direction, while observing the assumed instantaneous impact point location restriction if the launch site is located on Cape Kennedy. It should be noted, however, that southerly in-plane launches into polar or near polar orbits cannot be achieved from a Cape Kennedy launch site under the assumed restriction of overflying populous areas within 200 nm of the launch site.

3.0 TERRAIN MASKING

The current Space Shuttle Program requirements call for the Booster and the Orbiter to be provided with a capability for horizontal landing at the conclusion of their mission and with a go-around capability for a second landing approach in the event that a safe landing could not be achieved on the initial landing approach. A capability for ferry flights by the Booster and Orbiter between airports is also required. The Booster also must have the capability to return to the launch site. As indicated earlier, current planning has colocated the launch site and the primary recovery or landing site for the Space Shuttle. These requirements imply that both the Booster and Orbiter will be provided with air-breathing engines for use during subsonic cruise, landing approach, and landing phases of their mission. When in the subsonic flight regine during return from a space mission or during a ferry flight mission, it is expected that the Booster and the Orbiter will have flight characteristics comparable to those of conventional large aircraft. Landing approach glide slopes in the range of

2.5 to 3 degrees above the horizontal plane are currently used by conventional large aircraft. It should be noted that the go-around requirement for the Orbiter is currently being critically examined and consideration is being given to eliminating the air-breathing engines from the Orbiter when performing space missions. Hence, non-propulsive aerodynamic maneuvering by the Orbiter would be relied upon to reach the landing field and provide a safe, controlled landing. In this event, the nominal landing glide slope to be followed by the Orbiter will most likely be considerably higher, possibly in the area of 10 degrees above the horizontal plane. Use of this higher landing glide slope by the Booster is also being considered.

Using topographical maps of the areas surrounding the candidate sites of Cape Kennedy, Holloman AFB, and Edwards AFB, the masking (elevation angle above the horizontal plane) of the existing or assumed landing field location by the major natural terrain features with the greater altitudes in the area were calculated. It was determined that the terrain masking of a landing field at Cape Kennedy or at Edwards AFB for any given azimuth would never exceed 2 degrees. However, terrain masking of a landing field at Holloman AFB would exceed 2.0 degrees at selected azimuths in the azimuthal range extending from 20 degrees to 130 degrees (0 degrees corresponding to a due north direction) and exceed 2.5 degrees at selected azimuths in the range extending from 70 to 120 degrees being as much as 4 degrees in some instances. The natural features causing this masking are located approximately 15 statute miles from the assumed landing field location. This degree of terrain masking should not pose any serious problem unless the landing approach path to the Holloman AFB landing field to be used by the Space Shuttle falls within the azimuthal range extending from 70 to 120 degrees.

4.0 SUMMARY OF RESULTS

The orbit inclinations of major interest currently envisioned for Space Shuttle missions may be reached with an in-plane Space Shuttle launch in a net northerly direction from either a Cape Kennedy or an Edwards AFB launch site without the predicted instantaneous impact point of the Space Shuttle remaining within densely populated areas for unacceptably long time periods. It was assumed for the purposes of this analysis that the risk was acceptable if the predicted zerolift instantaneous impact point was progressing at a rate of at least the order of 3 nautical miles per second. Although the total number of inhabitants within a 230 statute mile radius of the Holloman AFB launch site is very much less than either for a Cape Kennedy or Edwards AFB launch site, the smaller number of densely popula-

ted areas are more evenly distributed in azimuth around the Holloman AFB site than around either of the other two potential launch sites. Consequently, under the assumed restriction on predicted instantaneous impact point location, difficulty may be encountered in achieving polar and/or sun synchronous orbits from a Holloman AFB launch site unless overflying Mexico during Space Shuttle launch powered flight is permitted. If overflying foreign controlled territories within 230 statute miles of the launch site is not permitted and non-safe aborts of the Space Shuttle are possible, a Cape Kennedy launch site appears to be more attractive than either an Edwards AFB or a Holloman AFB from a population safety standpoint.

Terrain masking at any azimuth at both the possible Cape Kennedy and Edwards AFB landing site locations will not interfere with a landing approach glide slope of 2.5 degrees, the nominal minimum landing approach glide slope used by current conventional large aircraft. Terrain masking at the possible Holloman AFB landing site location will most likely present a Space Shuttle safety problem only if the azimuth of the nominal landing approach path for the Booster or Orbiter lies between 70 and 120 degrees. Terrain masking at the Holloman AFB landing site location will present no problem if landing approach glide slope of the order of 10 degrees are used by both the Booster and the Orbiter.

A. G. Weygand

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Attachments
Tables 1, 2, 3
Figures 1, 2

Table 1

Assumed Launch Site - Cape Kennedy
Azimuth Locations of Incorporated Places
within 200 n.m. of Launch Site with Population Exceeding
10,000 and Corresponding Orbits Precluded for Inplane Launch

Incorporated City	Population (thousands)	Range (stat. mi.)	Azimuth (degrees)	Orb. Incl. (degrees)	Launch Direct North	Launch Direct South
Boca Raton, Fla.	28+	156				
Boynton Beach, Fla.	18-	147				
Coral Gables, Fla.	42+	197				
Deerfield Beach, Fla.	17-	159				
Delray Beach, Fla.	19-	150				
Fort Lauderdale, Fla.	139+	171				
Fort Pierce, Fla.	29-	80				
Hallendale, Fla.	24+	181				
Hialeah, Fla.	102-	188				
Hollywood, Fla.	104+	180				
Homestead, Fla.	13+	214				
Lake Worth, Fla.	23+	141				
Miami, Fla.	332-	194				
Miami Beach, Fla.	85+	192	164-176	76-86.5		x
Miami Springs, Fla.	13+	191				
Miramar, Fla.	24-	181				
North Miami, Fla.	35-	187				
North Miami Beach, Fla.	30+	185				
Oakland Park, Fla.	13+	167				
Opa-Locka, Fla.	12-	186				
Plantation City, Fla.	21+	170				
Pompano Beach, Fla.	38+	165				
Riviera Beach, Fla.	21+	128				
South Miami, Fla.	12-	202				
Vero Beach, Fla.	11+	67				
West Palm Beach, Fla.	57-	132				
Wilton Manors, Fla.	11-	170				
Melbourne, Fla.	40-	36				
Belle Glade, Fla.	16-	130	178-183	88-93		x
Eau Gallie, Fla.		30				
Cocoa, Fla.	16-	18	196-203	104-110		x
Rockledge, Fla.	10+	20				
Fort Meyers, Fla.	27-	157	208-210	114-116		x
Bartow, Fla.	13-	91				
Bradenton, Fla.	20+	143				
Pembroke Pines, Fla.	14+	94	234-239	135.5-139		x
Sarasota, Fla.	39-	146				
Winter Haven, Fla.	16-	80				
Clearwater, Fla.	51-	142				
Dunedin, Fla.	18-	140				
Lakeland, Fla.	41+	93				
Plant City, Fla.	15+					
Largo, Fla.	22+	142	244-254	142-147.5		x
St. Petersburg, Fla.	213+	145				
Tampa, Fla.	274+	122				

Table 1 (Cont.)

Incorporated City	Population (thousands)	Range (stat. mi.)	Azimuth (degrees)	Orb. Incl. (degrees)	Launch Direct North	Launch Direct South
Orlando, Fla.	98-	48				
Titusville, Fla.	30-	14	260-270	150-151.5		x
Winter Park, Fla.	22-	46				
Leesburg, Fla.	12+	80	280-281	149.5-150	x	
Sanford, Fla.	17+	45				
Ocola, Fla.	22+	102	287-291	145-147	x	
DeLand, Fla.	11+	52				
Gainesville, Fla.	64-	127	302-306	135.5-138	x	
Valdosta, Ga.	31+	220				
Lake City, Fla.	10+	164	311-314	129-131.5	x	
Palatka, Fla.	10-	94	318-319	125-126	x	
Daytona Beach, Fla.	44+	49				
Jacksonville, Fla.	513+	140				
New Smyrna Beach, Fla.	10+	35	323-336	111-122	x	
Ormand Beach, Fla.	15-	54				
St. Augustine, Fla.	12+	98				
Waycross, Ga.	19-	205				
Brunswick, Ga.	19+	180	343-344	104-105	x	

Table 2

Assumed Launch Site - Holloman Air Force Base
Azimuth Locations of Incorporated Places
within 200 n.m. of Launch Site with Population Exceeding
10,000 and Corresponding Orbits Precluded for Inplane Launch

Incorporated City	Population (thousands)	Range (stat. mi.)	Azimuth (degrees)	Orb. Incl. (degrees)	Launch Direct North	South
Santa Fe, N. Mex.	39+	190	1-3	87-89	x	
Clovis, N. Mex.	28+	192	55-56	46-47	x	
Roswell, N. Mex.	33-	100	65-67	39-40.5	x	
Alamagordo, N. Mex.	23-	11	↑	↑		
Levelland, Tex.	11+	215	70-80	34-38	x	
Lubbock, Tex.	146+	240	↓	↓		
Artesia, N. Mex.	10+	100	88-90	33	x	
Lamesa, Tex.	11+	230	↑	↑		
Hobbs, N. Mex.	26-	167	91.5-92.5	33		x
Carlsbad, N. Mex.	21-	112	↓	↓		
Midland, Tex.	58+	230	103.5-107	35.5-36.5		x
Odessa, Tex.	76+	220	↑	↑		
Pecos, Tex.	12+	175	122-123	44.5-45		x
El Paso, Tex. and Ciudad Juarez, Mex.	317+	72	190-200	98-106.5		x
Las Cruces, N. Mex.	38-	51	222-228	124-128.5		x
Douglas, Ariz.	12+	220	243-244	138.5-139		x
Gallup, N. Mex.	14-	227	321-322.5	121-122	x	
Albuquerque, N. Mex.	242+	150	347-351	97.5-101	x	

Table 3

Assumed Launch Site - Edwards Air Force Base
Azimuth Locations of Incorporated Places
within 200 n.m. of Launch Site with Population Exceeding
10,000 and Corresponding Orbits Precluded for Inplane Launch

Incorporated City	Population (thousands)	Range (stat. mi.)	Azimuth (degrees)	Orb. Incl. (degrees)	Launch Direct North	Launch Direct South
China Lake, Cal.		51	11-13	79-81	x	
Las Vegas, Nev.	124+	172				
North Las Vegas, Nev.	35+	174	58-61	44-46	x	
Henderson, Nev.	16+	178				
(Hoover Dam)		189	63-66	41-43	x	
Barstow, Cal.	17+	46	90-92	35		x
Yuma, Ariz.	29-	236	128-129	50-50.5		x
Victorville, Cal.	11-	40	130-131	51-51.5		x
Indio, Cal.	14+	122	132-133	52-53		x
Brawley, Cal.	14-	186				
Calexico, Cal.	11-	202	134-140	54-58		x
El Centro, Cal.	19-	195				
Palm Springs, Cal.	20+	105				
Banning, Cal.	12-	86	142-143	59.5-60.5		x
Alhambra, Cal.	61+	59				
Anaheim, Cal.	165+	74				
Arcadia, Cal.	45-	54				
Artesia, Cal.	15-	73				
Azusa, Cal.	25+	54				
Baldwin Park, Cal.	48-	56				
Bell, Cal.	22-	68	146-225	63-125		x
Beverly Hills, Cal.	33-	64				
Brea, Cal.	19-	68				
Buena Park, Cal.	64-	72				
Burbank, Cal.	89-	56				
Carlsbad, Cal.	15-	123				
Chino, Cal.	20-	61				
Chula Vista, Cal.	64+	165				
Claremont, Cal.	24-	56				
Colton, Cal.	22-	64				
Compton, Cal.	75+	73				
Corona, Cal.	27+	73				
Coronado, Cal.	18+	157				
Costa Mesa, Cal.	72+	86				
Covina, Cal.	29+	57				
Culver City, Cal.	35+	68				
Downey, Cal.	88-	70				
Duarte, Cal.	15-					
El Cajon, Cal.	58+	152				
El Monte, Cal.	71-	60				
El Segundo, Cal.	15+	76	146-225	63-125		x
Escondido, Cal.	36+	129				

Table 3 (cont.)

Incorporated City	Population (thousands)	Range (stat. mi.)	Azimuth (degrees)	Orb. Incl. (degrees)	Launch Direct North	Launch Direct South
Fontana, Cal.	20+	60				
Fullerton, Cal.	85-	71				
Gardena, Cal.	41+	76				
Garden Grove, Cal.	122-	79				
Glendale, Cal.	132-	58				
Glendora, Cal.	32-	53				
Hawthorne, Cal.	53+	75				
Hemet, Cal.	12+	94				
Hermosa Beach, Cal.	17+	79				
Huntington Beach, Cal.	116-	85				
Huntington Park, Cal.	35-	67				
Imperial Beach, Cal.	20-	164				
Inglewood, Cal.	89-	71				
Laguna Beach, Cal.	14+	94				
La Habra, Cal.	41+	67				
Lakewood, Cal.	82+	74				
La Mesa, Cal.	39-	153				
La Puente, Cal.	31+	62				
La Verne, Cal.	15-	56				
Long Beach, Cal.	347-	85				
Los Alamitos, Cal.	11-	76				
Los Angeles, Cal.	2,782-					
Lynwood, Cal.	43+	69				
Manhattan Beach, Cal.	35-	78	146-225	63-125		x
Maywood, Cal.	17-	67				
Monrovia, Cal.	30-	53				
Montclair, Cal.	22+	58				
Montebello, Cal.	43-	63				
Monterey Park, Cal.	49-	61				
National City, Cal.	39-	158				
Newport Beach, Cal.	49-	88				
Norco, Cal.	14+	69				
Norwalk, Cal.	91+	71				
Oceanside, Cal.	41-	120				
Ontario, Cal.	64+	61				
Orange, Cal.	76+	77				
Palos Verdes, Cal.	13+	84				
Paramont, Cal.	34+	71				
Pasadena, Cal.	112-	56				
Pico Rivera, Cal.	54-	64				
Pomona, Cal.	88+	58				
Redlands, Cal.	37-	69				
Redondo Beach, Cal.	57-	80				

Table 3 (Cont.)

Incorporated City	Population (thousands)	Range (stat. mi.)	Azimuth (degrees)	Orb. Incl. (degrees	Launch Direct North	South
Rialto, Cal.	29-	61				
Riverside, Cal.	139+	68				
Rosemead, Cal.	39-	60				
San Bernadino, Cal.	107-	57				
San Clemente, Cal.	16+	103				
San Diego, Cal.	676-	155				
San Fernando, Cal.	17-	55				
San Gabriel, Cal.	29+	58				
San Marino, Cal.	14-	56	146-225	63-125		x
Santa Ana, Cal.	155-	80				
Santa Fe Springs, Cal.	15-	66				
Santa Monica, Cal.	87+	71				
Seal Beach, Cal.	24+	81				
Sierra Madre, Cal.	12-	54				
South El Monte, Cal.	15+	62				
South Gate, Cal.	56+	69				
South Pasadena, Cal.	23-	58				
Stanton, Cal.	18+	77				
Torrance, Cal.	136-	79				
Tustin, Cal.	21-	80				
Upland, Cal.	33-	55				
Vista, Cal.	25-	122				
West Covina, Cal.	68-	58				
Westminister, Cal.	60-	80	146-225	63-125		x
Whittier, Cal.	67+	65				
Yorba Linda, Cal	12-	69				
Camarillo, Cal.	19+	83				
Oxnard, Cal.	70+	88				
Port Huenue, Cal.	15-	92				
Santa Paula, Cal.	18-	79	228-244	128.5-138		x
Simi Valley, Cal.	61-	72				
Thousand Oaks, Cal.	34+	76				
Ventura, Cal.	57+	93				
Santa Barbara, Cal.	70-	111	252-254	141.5-142		x
Lompoc, Cal.	24-	147	262-264	145		x
Santa Maria, Cal.	32+	145	271-272	145	x	
San Louis Obispo, Cal.	28-	160	279-280	145	x	
Bakersfield, Cal.	70-	67	294-300	135-139	x	
Delano, Cal.	14+	97	308-309	129-130	x	
Atwater, Cal.	12-	225				
Clovis, Cal.	13+	165				
Fresno, Cal.	162+	163				
Hanford, Cal.	15+	138				
Madera, Cal.	16-	185	315-324	119-125	x	
Merced, Cal.	23-	217				
Porterville, Cal.	12+	102				
Tulare, Cal.	16+	121				
Visalia, Cal.	27+	125				

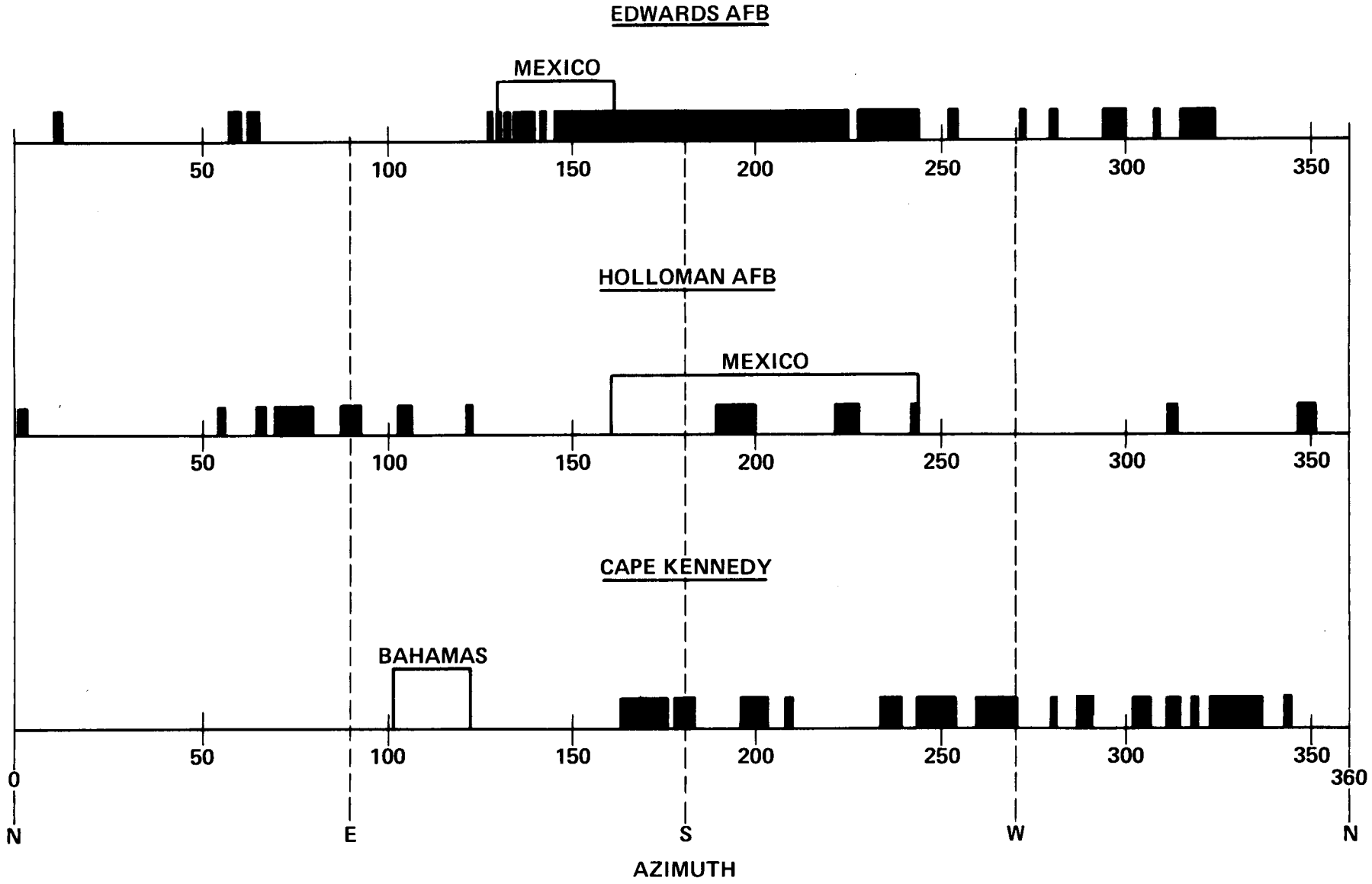

FIGURE 1 - AZIMUTH LOCATIONS OF INCORPORATED PLACES WITHIN 200 N. MI. OF LAUNCH SITE WITH POPULATION EXCEEDING 10,000

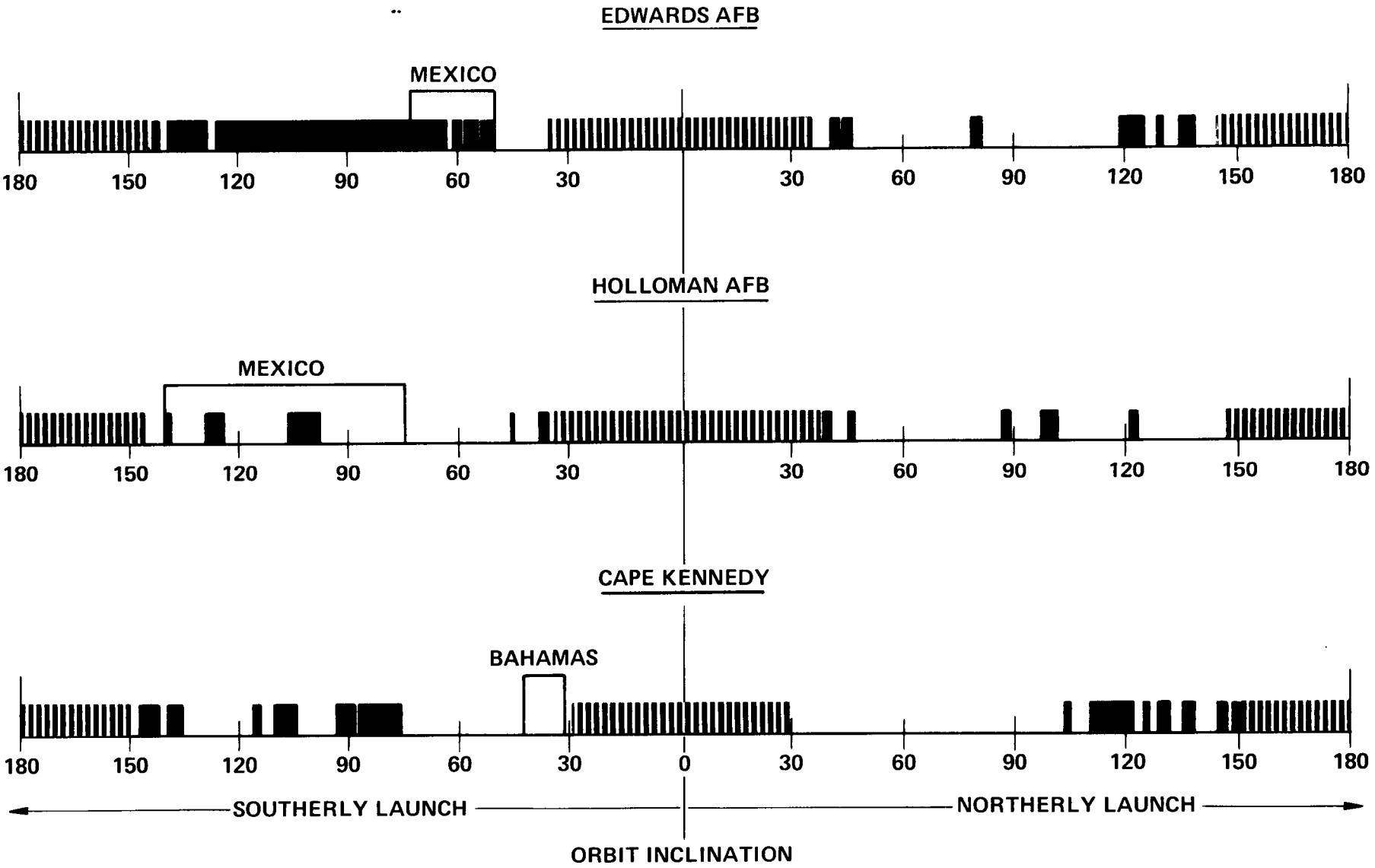

FIGURE 2 - ORBITS PRECLUDED FOR INPLANE LAUNCH IF CITIES WITHIN 200 N. MI. OF LAUNCH SITE WITH POPULATION EXCEEDING 10,000 ARE NOT OVERFLOWN